January 2001

Evaluation of 1996 Beef Cattle NRC Model and Development of Net Energy Modifiers

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Accuracy of 1996 NRC model gain predictions may be improved by use of equations to predict appropriate net energy adjusters.

Summary

Data from 325 treatment means in 35 previous beef cattle feeding studies were used to evaluate the 1996 NRC model for accuracy of gain predictions and to develop predictions of net energy adjusters for use with the model. The model was found to inaccurately predict gain of cattle fed diets varying in ingredients and energy density. Net energy adjusters were used to achieve accurate prediction of gain for each observation and then equations were developed for predicting the level of net energy adjustment required to improve accuracy of gain prediction.

Introduction

The National Research Council's (NRC) 1996 Nutrient Requirements of Beef Cattle model has previously been shown to inaccurately predict the gain of cattle on low to medium energy diets (2000 Nebraska Beef Report, pp. 26-29). It is hypothesized that the inaccuracy in gain prediction can be attributed to the development of the net energy equations from a high energy data set that was unequally distributed (Garrett, 1980, pp. 3-7 in Energy Metabolism). Level 1 of the NRC model contains net energy adjusters that can be used to achieve accurate prediction of gain by altering the net energy values of the diets. The objective was to use previous cattle feeding data from the University of Nebraska to develop equations to predict the level of net energy adjustment required to improve accuracy of gain predictions.

Procedure

A total of 201 treatment means from 31 different growing trials and 124 treatment means from four different finishing trials conducted at the University of Nebraska and reported previously were used in evaluating gain predictions by the 1996 NRC model. The same data set was also used for developing equations to predict the level of net energy adjustment required to achieve accurate gain predictions.

Cattle weights, diets and use of implants and ionophores were used as model inputs. Energy density of diets was determined from published results, including IVDMD, or from 1996 NRC feed table TDN values. All analyses were under the assumption of thermal neutral conditions of 68°F with no wind. Final shrunk body weight (FSBW) for the finishing trials was determined from carcass weight and a common carcass dress of 63%. Data were not available for FSBW in the growing trials or body conditions score (BCS) in the growing and finishing trials, and were consequently set to a FSBW equal to the average of the finishing trials (1189 lb) for the growing trials, and a default BCS of 5 for both the growing and finishing trials. Sensitivity of gain predictions to $\pm$10% changes in FSBW, BCS, and the DE to ME conversion of 0.82 was evaluated. The procedures of Mayer and Butler (1993, Ecological Modeling 68:21-32) were used to evaluate the accuracy and precision of gain predictions.

Subsequent to evaluation of gain predictions, the net energy adjusters were used to alter predicted gains to agree with observed gains. There are separate adjusters for NEm and NEg, with upper and lower limits of 120% and 80% of predicted NEm and NEg, respectively. Use of the model equations, but not the 1996 NRC model computer program, allowed these limits to be exceeded. Adjustment was applied equally to NEm and NEg. Resulting adjuster levels were then regressed against observed ADG, total TDN intake, and TDN concentration to develop equations for the level of adjuster required to improve accuracy of gain predictions.

Results

The data set used in evaluating the 1996 NRC model is described in Table 1. Use of implants or ionophores was found to be documented with only 6 and 62, respectively, of growing trial treatment means. All finishing trial treatments made use of implants and ionophores.

The ratio of ME to DE is about 0.80 but can range considerably depending on intake, age of animal, and feed source (NRC, 1996). With the ME to DE ratio

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Table 1. Data used in 1996 NRC model evaluation and NE adjuster equation development.

Parameter	Average	SD	Minimum	Maximum
Average weight, lb				
Growing, n=201	609.3	66.3	481.6	820.0
Finishing, n=124	958.8	69.5	731.0	1104.0
Daily gain, lb				
Growing, n=201	1.56	0.66	0.27	3.00
Finishing, n=124	3.51	0.41	2.64	4.48
DMI, lb				
Growing, n=201	14.62	3.18	8.60	20.90
Finishing, n=124	26.06	2.57	17.20	30.90
TDN, %				
Growing, n=201	61.6	7.3	42.7	75.4
Finishing, n=124	82.7	0.4	82.5	84.5
FSBW, lb				
Finishing, n=124	1188.7[a]	84.8	914.0	1369.0

[a]Value used as FSBW for growing cattle observations.

Table 2. Distribution of observations within data sets by energy density as a percent of the total.

Diet TDN, %	<53	53-72	72-80	>80
Garrett (1980)	1%	22%	65%	12%
UNL data set[a]	8.62%	48.92%	4.31%	38.15%

[a]University of Nebraska, Lincoln, n = 325.

Table 3. Sensitivity of gain predictions to changes in BCS, FSBW, or DE to ME conversion.

Parameter	Change in parameter	Change in gain prediction
BCS	+10%	-1.5%
	-10%	+1.5%
FSBW	+10%	+6.7%
	-10%	-7.0%
DE to ME conversion	+10%	+24.1%
	-10%	-24.5%

Table 4. NE adjuster equations[a] based on ADG, TDN intake, and TDN concentration.

Parameter used as X	a	SE	k	SE	b	SE
ADG[b]	0.8479	0.0669	0.2133	0.1521	0.6327	0.0962
TDN intake[c]	3.476	0.470	0.1341	0.0247	0.7705	0.0151
TDN concentration[d]	183.0	50.0	4.780	0.570	0.7628	0.0135

[a]Equations are of the form: $y = a \times 10^{(-k\ X)} + b$
[b]ADG, lb/day.
[c]TDN intake, lb/day.
[d]TDN concentration, lb/lb of DM.

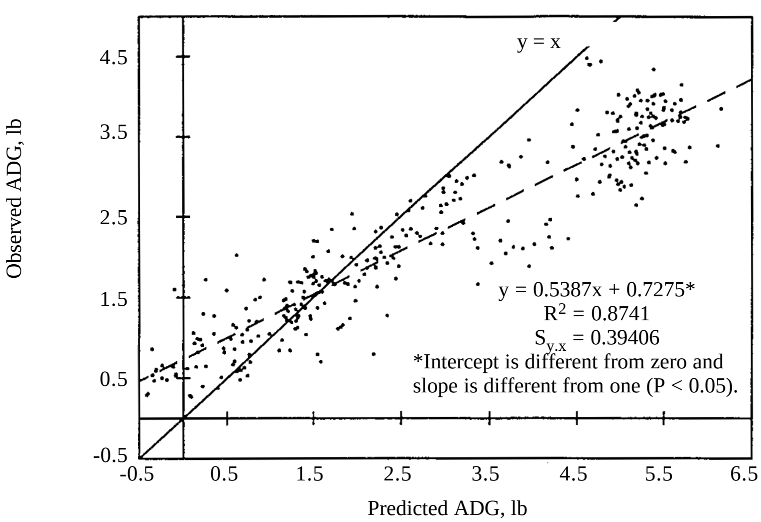

Figure 1. Accuracy of gain predictions. Each point represents a treatment mean (n=325).

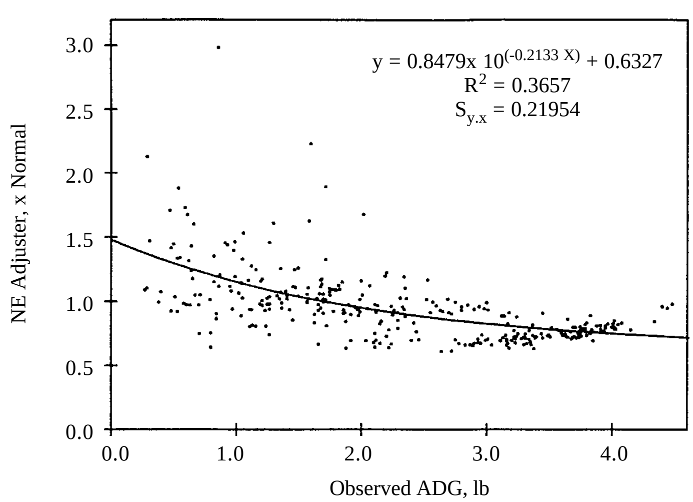

Figure 2. Prediction of NE adjuster from observed ADG. Each point represents a treatment mean (n=325).

set at 0.82, the range in ME to DE ratio in response to changing feed sources, with different levels of fiber, starch and fat, is effectively transferred into the equations that predict NEm and NEg from ME. Therefore, the range in diet energy densities used in predicting NEm and NEg from ME is particularly important. Garrett (1980) developed the equations to predict NEm and NEg from a data set with unequally distributed and high energy density, whereas this evaluation makes use of a data set with diets having a greater range in energy densities (Table 2). The data set used in this evaluation is more evenly distributed between high (>80% TDN) and moderately low (53-72% TDN) energy diets, but has relatively few observations at moderately high (72-80% TDN) and very low (<52% TDN) energy diets.

Sensitivity analysis of gain predictions to changes in FSBW, BCS, and the DE to ME conversion of 0.82 found predictions to be relatively insensitive to changes in FSBW and BCS but very sensitive to changes in the DE to ME conversion factor (Table 3). However, FSBW, BCS, and the DE to ME conversion of 0.82 are not likely to have the same relative level of variation.

Gain predictions were found to be precise with an R^2 of 0.8741, but inaccurate, as the least squares regression equation (intercept = 0.7275, slope = 0.5387) was different ($P < 0.05$) from the isopleth (intercept = 0, slope = 1) (Figure 1).

All predictions were made under thermal neutral conditions that would maximize the prediction and contribute to inaccurate prediction any time the environment was severe enough to affect performance. Therefore, over prediction of gains can be expected by assuming thermal neutral conditions. More effective modeling of environmental effects on gains by growing cattle would bring observed and predicted gains into closer agreement for rapidly gaining cattle where gains were over predicted, but would result in greater discrepancy between observed and predicted gains for slowly growing cattle where gains were under predicted.

Exponential equations were used to fit observed ADG, TDN intake, or TDN concentration to determined NE adjust-

ers. The relationship between determined NE adjuster and ADG existed ($P < 0.05$), but was quite weak ($R^2 = 0.3657$; Figure 2). A stronger relationship ($P < 0.05$; $R^2 = 0.6441$; Figure 3) existed with TDN intake. However, use of TDN intake to predict NE adjusters will be confounded by total DMI. The strongest relationship was with TDN concentration ($P < 0.05$; $R^2 = 0.7707$; Figure 4). All equations are presented in Table 4.

The equations relating ADG, TDN intake, or TDN concentration to NE adjusters may be used to improve the accuracy of gain predictions by the 1996 NRC model. Consequently, a table of recommended adjusters (Table 5) based upon the equations derived to relate the required NE adjuster to ADG, TDN intake and TDN concentration was developed. It is important to note that the recommended NE adjusters do extend beyond the range of 80 to 120% of normal allowed by the 1996 NRC model computer program.

As an example, if a group of cattle are to be fed a diet with a TDN concentration of 65.9%, (NEm = 0.68 Mcal/lb, NEg = 0.41 Mcal/lb), the appropriate NE adjuster to enter into the NRC model is 0.89, resulting in an adjusted NEm of 0.61 Mcal/lb and an adjusted NEg of 0.37 Mcal/lb. These adjusted NE values are then used in the prediction of gain, and should result in a more accurate prediction of gain.

While the strongest relationship to the required NE adjuster was found with TDN concentration, use of TDN intake equations may still be advisable, particularly in situations where observed gains are likely to be confounded by DMI that is considerably higher or lower than what would normally be expected. Regardless of the basis selected, caution is recommended when using the equations as they reflect any limitations in the data from which they were derived, and are appropriate only over the range of values from which they were defined. Whereas there are numerous observations at high rates of gain, high TDN intakes, and high TDN concentrations, we have confidence in the NE adjuster predictions at that end of the scale. However, due to fewer observations at low rates of gain, low TDN intakes, and low TDN concentrations, less confidence is held with NE adjuster predictions at this end of the scale.

Table 5. NE adjuster values based on ADG, TDN intake, or TDN concentration[a].

ADG[b]	NE adjuster[c]	TDN intake[d]	NE adjuster[c]	TDN concentration[e]	NE adjuster[c]
0.27	1.38	6.00	1.32	0.500	1.51
0.74	1.22	8.17	1.05	0.538	1.25
1.21	1.10	10.34	0.91	0.577	1.08
1.67	1.01	12.51	0.84	0.615	0.97
2.14	0.93	14.68	0.81	0.653	0.90
2.61	0.87	16.84	0.79	0.692	0.85
3.08	0.82	19.01	0.78	0.730	0.82
3.54	0.78	21.18	0.78	0.768	0.80
4.01	0.75	23.35	0.77	0.807	0.79
4.48	0.73	25.52	0.77	0.845	0.78

[a]ADG, TDN intake, or TDN concentration predictions of NE adjuster are not intended to match across rows.
[b]ADG, lb/day.
[c]Predicted NE adjuster, decimal form.
[d]TDN intake, lb/day.
[e]TDN concentration, lb/lb of DM.

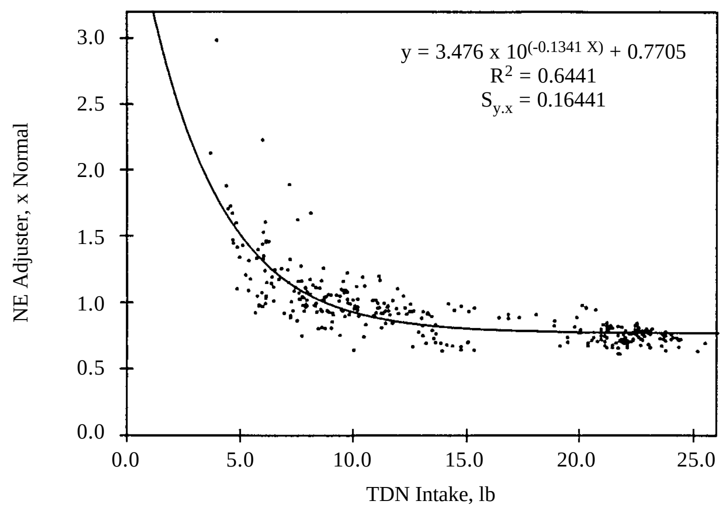

Figure 3. Prediction of NE adjuster from TDN intake. Each point represents a treatment mean (n=325).

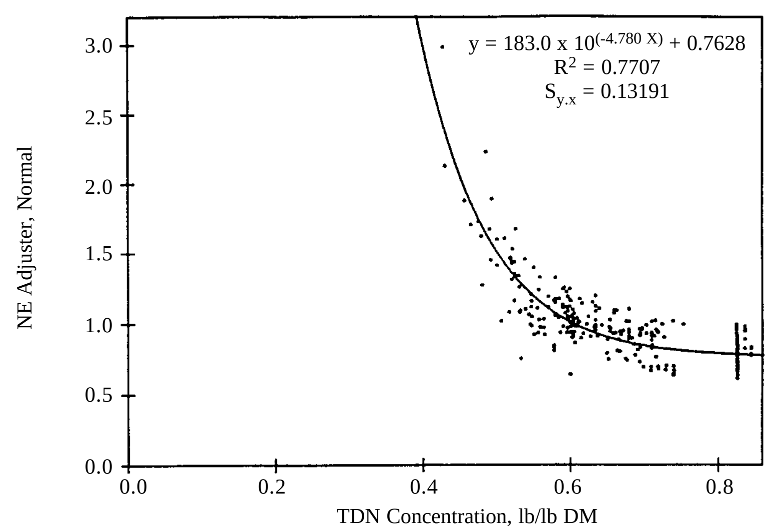

Figure 4. Prediction of NE adjuster from TDN concentration. Each point represents a treatment mean (n=325).

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